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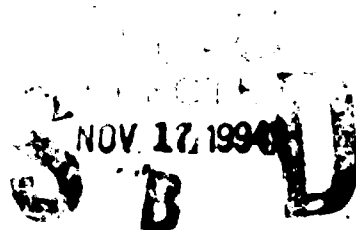
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Technical Report ARFSD-TR-94014

**INTERIM PRODUCTION OF THE AN/ALM-262:
MANUFACTURING PROBLEMS AND SOLUTIONS**

John Antonacos



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INTRODUCTION

In January 1993, an in-house effort was begun at ARDEC to build 150 countermeasure dispenser test sets (CDTS) (AN/ALM-262) for the Air Force's Air Logistic Center, San Antonio, Texas. The CDTS is used to test countermeasure dispenser sets (CMDS). The CMDS is a novel system designed to dispense decoy flares and/or chaff from military aircraft. This system provides effective survival countermeasures against radar-guided weapon systems and/or heat-seeking missile threats.

The Air Force established the following requirements for the desired CDTS:

- Go/no-go simplistic operation philosophy
- Easy maintenance
- Dispenser system-not-reset indication
- Stray voltage indication
- All fire pulses present at the output indication
- Blink indication for each correct fire pulse output
- One-ohm load simulation
- Internal and external aircraft power operation
- MIL-STD-810C requirements
- Level III technical data package
- Weigh less than 20 lb
- Two test sets and accessories per carrying case

The manufacture of 150 CDTS was known as the interim build. This technical report is concerned with the manufacturing problems and the solutions encountered during the interim build.

BACKGROUND

In the early 1970s, the Air Force developed and fielded the AN/ALE-40 CMDS. Between 1974 and 1978, the U.S. Army Armament Research, Development and Engineering Center (ARDEC) developed the M130 CMDS, which was fielded in 1979. Between 1978 and 1979, ARDEC developed two testers (M91 and M92) to support the M130. The M91 was for testing on the flight-line, while the M92 was for depot testing. Both testers were fielded in 1979. In 1983, the Air Force fielded a computerized CMDS, the AN/ALE-45. In 1991, the Air Force qualified a smart CMDS, the AN/ALE-47.

Late in 1989, the Air Force concluded that their CMDS equipment had various deficiencies. The Air Force was aware of the M91's capability and approached ARDEC to see if they were willing to adapt the M91 to Air Force requirements. The Army and Air Force CMDS are similar, one being the offshoot of the other; both having been designed by TRACOR, Inc. of Austin, Texas.

ARDEC agreed to develop a CDTs capable of testing the AN/ALE-40, -45, and -47 CMDS. ARDEC developed the AN/ALM-262 during 1990 and 1991, detailing the effort to the Air Force in the customary concept, preliminary, and critical design reviews.

After the prototype was demonstrated, the Air Force decided that the blinking light emitting diode (LED) method of testing fire pulses was too slow. A digital readout for defective fire pulses was proposed as a rapid test method. ARDEC agreed to design a CDTs with a digital readout, which was designated the AN/ALM-262A. Although, externally this CDTs looks only slightly different from the AN/ALM-262, it is essentially a new design, since 90% of the circuitry is new.

Since the Air Force was greatly in need of a suitable CDTs, it was decided that ARDEC would do an interim build of 150 AN/ALM-262s, to tide them over until such time that the production of the ALM-262A would start.

The understanding between the Army and the Air Force was formalized by a Memorandum of Agreement (MOA), signed by the Generals of ARDEC and SA-ALC on June 12, 1992.

MANUFACTURING PROBLEMS AND SOLUTIONS

The manufacture of the ALM-262 was performed in *Buildings 95 and 1530* at ARDEC. Personnel from Building 95 built the six different printed circuit boards (PCB), assembled the wire harnesses, and wired the base plates. Integration of the subassemblies and housing assemblies and the PCB and CDTs testing were done in Building 1530.

The unique mechanical parts of the ALM-262 were manufactured by Nomura Enterprise Inc. (NEI) of Dover, New Jersey. This company also generated all the drawings for the required technical data package. The overall views of the AN/ALM-262 are shown in figure 1. The details of the test set are presented in figure 2. The problems encountered in manufacture of the AN/ALM-262 were of three types: mechanical, electrical, and testing. These problems and solutions will be presented.

Final Assembly

The AN/ALM-262 had 27 components mounted within the housing. After a number of units were completely assembled, it was found that the most common screw used, MS21093-0411, was not suitable in a number of areas.

One place where this screw had to be changed was where it is used to mount the flange assembly on the housing. The bottom view of the AN/ALM-262 (fig. 3) shows how the flange assembly is attached to the housing. Ten screws were used for its mounting. It was found that the five screws nearest the front were to close the toggle and rotary switches, and could cause physical damage and shorts. These five screws were changed to a shorter type, MS21093-0406.

The mounting of the one-ohm load resistor (fig. 3) encountered another problem with the screws. There were two screws that pressed on the resistor radiation fins making mounting difficult. When these screws were changed to shorter ones, MS21093-0407, this problem was eliminated.

Lastly, the screw that held the ground lug (fig. 3) was changed to MS21093-0406 for aesthetic purposes.

Housing

Nomura Enterprise Inc. encountered difficulties in the manufacture of the housing from the beginning of their contract. The lettering on the housing was smeared, irregular, and not engraved to the right depth. The housing, as designed, was to be black anodized with white lettering. They suggested two additional methods to solve the engraving problem. One method was to use a nonanodized stainless steel housing with black lettering. Another method was to engrave the lettering on a black plastic plate, which would then be glued to the front panel.

After housings were made with the three methods, ARDEC decided that the stainless steel housing resulted in the best lettering, and recommended that the Air Force adopt this type of housing. ARDEC and NEI decided that an engraving specialist could make the lettering even better, and consequently NEI subcontracted the Hanover Engraving Co., Hanover, New Jersey to engrave housings concurrently with NEI. This company has produced excellent engraving and the NEI engraving has improved greatly. Based on these results, ARDEC convinced the Air Force to accept the stainless steel housing for the interim build.

Another problem with the housing was the seven radial markings of the test sequence switch. As the markings were originally laid out, the circumferential distances between two adjacent markings were not the same number of degrees as any other adjacent set. Consequently, the knob pointer did not line up well with some of the markings. Unfortunately, quite a number of the housings were made before this error was discovered and the housing drawing modified. An additional benefit of the modified version of the front panel was larger lettering, making for easier reading.

Identification Plate

East test set as originally designed had an identification plate affixed to its right side. This is shown in the right-hand view of figure 2. After a number of test sets were built and continually inserted into a dispenser assembly for functional PCB or test set testing, it became apparent that in a short time the identification plate became either defaced or completely worn off. The problem was solved by moving the identification plate to the left center of the front panel.

Mounting Bar

There was a general problem in the assembling of the housing. The screws used for this were coated with lock-tight. This material keeps a screw from unscrewing once it is tightened. One place where these screws were used was to attach the mounting bars to the housing. The top view of figure 2 shows the location of the two mounting bars. Their function was to hold the base plate onto the housing. The threads in the mounting bar had been well cut, but because of the length that the lock-tight must pass through, in most cases, the screw jammed before it was screwed all the way down. By applying more force, the screw could be made to go all the way down, but not without noticeable damage to the Phillips cross in the screw head. The screw would hold properly, but the visibly bad workmanship could not be allowed. To alleviate the problem, the threads of each mounting bar were rethreaded using a tapping tool.

Impulse Cartridge Simulator

The impulse cartridge simulator (ICS) was a terminal system, mounted on the base plate of the test set, that received the fire pulses from the dispenser system. Since there were 30 per test set, 5,000 had to be manufactured for 150 AN/ALM-262s and ten AN/ALM-262As.

The ICS is shown in figure 4. It consisted of three parts: the body, the center terminal (+), and the side terminal (-). A small, plain metal terminal, knurled at one end, was manually pressed into the small hole shown. There were no assembly problems with this terminal. The center terminal, though, was more massive and consisted of a metal stem surrounded by a plastic insulator ring. This terminal was assembled into the ICS body by pressing with an arbor press. Some distortion and/or damage had to occur to the plastic ring because it was held in place under pressure.

In the beginning of manufacture, the rejection rate of the ICSs were excessive: one out of five. The plastic ring would either crack or come off completely during assembly. This damage was caused by unequal pressure being applied while pressing the arbor press arm. The rejection rate was cut in half by doing two things: various arbor press bits were used to find the one giving the best results and the bits were continuously greased during the operation to assure smooth operation.

On/Off Switch

The power on/off switch is shown in figure 5. It was mounted by two screws on the right-hand wall of the housing. The switch was activated by a dowel in the dispenser assembly, which pushed the switch lever whenever the test set was mounted.

There were two kinds of switch failures that did not allow the power to come on when the lever was activated. In one case, the miniature push-button on the switch was not properly depressed by the lever. The tolerances of the dowel and the switch lever are such that the dowel, at times, would not press the lever sufficiently. This problem was handled by the assembler assuring the lever was in the proper position and it had the proper swing.

The second failure was due to an internally damaged switch. The switch could be damaged by overheating when soldering wires on its terminals. Since the switch is small and delicate, heating the terminals excessively when soldering could melt its plastic parts slightly, thereby causing faulty operation. The solution to this problem was to instruct the assemblers to exercise more care when soldering.

Knob Assembly

This assembly is shown in figure 6. It consisted of a knob, a setscrew, and a hexhead. The assembly was made by removing the hexhead from a hexhead bolt and gluing it in the position shown in the figure. All the switches on the test set contained a hexhead. The hexhead was used to enable operation of the switches at a greater distance from an aircraft than could be done by just using the hands, through the use of a hexhead driver.

The knob had an assembly problem. The knob was attached to the rotary switch shaft by the use of two setscrews. The setscrews did not grip the shaft as well as they could for two reasons. First, the setscrew did not have sufficient contact surface. Second, there was a slot in the shaft that allowed even less contact surface in those cases where the setscrew touches the edge of the slot.

To get a larger setscrew contact surface, a larger diameter setscrew was obtained and the knob setscrew hole was made larger. The slot problem could not be solved for the interim build since all switches were ordered, but the technical data package for the ALM-262A has drawings with slotless rotary switches.

Chassis Assembly

The chassis assembly is shown in figure 7. Its function was to hold four PCBs. It was attached to the top of the housing with 10 screws. The top access cover assembly

(fig. 8) was held on the housing by screwing lock-tight coated screws into the floating clinch nuts of the chassis assembly. The nuts were attached to the flange part of the chassis by peening out their edges.

Two problems were encountered with the nuts. The first was that some nuts fell out after being attached to the flange. The causes of this were either the nut and the flange hole were out of tolerance, or the nut was not peened sufficiently. The solution to this problem was to examine the peening carefully to assure it was done properly.

The second problem was improperly made nuts; either the threads were missing from the metal part of the nut, or the plastic part was too large. The solution to this problem was to screw a screw into each nut and observe if the threads would engage properly.

Flange Assembly

The flange assembly is shown in figure 9. It was attached to the bottom of the housing with 10 screws. The bottom access cover assembly (fig. 10) was held on the housing by screwing lock-tight coated screws into the clinch nuts of the flange assembly.

The nuts are the same as those used on the chassis assembly and, consequently, posed the same problems. The solutions to these problems are those described under the Chassis Assembly section.

It must be noted, though, that for both the chassis and flange assemblies, it is imperative that the problem be found and corrected before assembly into the housing. During manufacture there were four cases where there was a nut problem after final assembly. The work to remove the assembly was slow and tedious, and could result in broken solder connections. To assure that the nuts were properly made and fastened to the chassis or flange assembly properly, they must be checked with screws prior to final assembly.

Voltage Regulator Assembly

The voltage regulator assembly is shown in figure 11. It consists of a voltage regulator, two thermal power cooler parts; i.e., heat sinks, and a mounting bracket. The cooler parts are black anodized. This part as shown in the lower view of the figure has to make electrical contact with two screws. Therefore, each of its ends had to be filed to remove the anodization. To eliminate this tedious and time consuming operation, the cooler drawing was changed to remove the anodization of the cooler parts.

Top Access Cover Assembly

Again, referring to the top access cover assembly in figure 8, the top access cover and pad bracket are riveted together with four rivets. The riveting was done by the Ammunition Engineering Directorate machine shop in building 3150. The cost to get properly riveted parts was excessive. In future production, the company making these two parts will also be contracted to rivet them together.

A porous plastic pad which was epoxied on the pad bracket is shown in figure 8. This pad presses against and cushions the PCBs. The original epoxy did not hold the pad well and after experimentation a proper epoxy was found.

Bottom Access Cover Assembly

Two battery holders are riveted to the bottom access cover using eight rivets as shown in figure 10. As in the case of the top access cover assembly, the riveting costs were excessive and it is recommended that the parts manufacturer do the riveting.

The battery holders have two problem areas. One problem concerns the clip terminals that snap on the battery terminals. They are difficult to align so the battery snaps in easily. Pushing the battery in at an angle may permanently damage part of the terminal, making a weaker connection. Another problem was that the solder terminals, that attach to the clip terminals, have some play in them. Since there are a number of jumper wires between the two battery holders, a terminal inadvertently pushed at an angle could cause a short circuit. The battery holder needs to have harder and more rigid terminals. Therefore, a better battery holder is needed. A search should be made to determine if one is available for application to the AN/ALM-262A.

Base Plate Assembly

The base plate assembly is shown in figure 12. The base plate holds 30 ICSs and four grounding screw assemblies. Two changes were made to this assembly to improve it mechanically and electrically.

The upper view of figure 12 shows a screw in the upper central area of the base plate. This screw together with a tie anchor, a tie down strap, and a nut hold the wire harness onto the base plate. After a number of test sets were made, it was seen that the harness was not clamped at the best place. A new hole was put in the bottom central area of the base plate and the old hole was sealed.

The bottom view of figure 12 shows a cutaway view of one of the four grounding screw assemblies. When the first test sets were built, some of the grounding screws did not appear to touch their respective dispenser assembly pins, which did not allow

the required grounding action to occur. The two causes for this were either the screw was not sufficiently long or the end of the screw did not make good contact. The solution for the first probable cause was to use a longer screw which cured the problem. To assure even better contact in the ALM-262A, the screw will be made a hexhead type and turned around so that the contact area of the pin will be the whole hexhead.

Bracket Assembly

The bracket assembly, also called the plunger switch, is shown in figure 13. There are four wide and one narrow switch per test set. They are set in accordance with the CMDS that is tested; the ALE-40, -45, or -47. The switch consists of four manufactured and three military specification parts. There were 760 of these switches assembled in-house.

Two improvements can be made to the switch to aid future production. Mounting the switch on the housing currently requires four sets of screws and nuts. If the four mounting holes were threaded, the mounting nuts could be eliminated making assembly easier. The four switch holes are on the support plate part. To be ready for future production the support plate drawing was modified to add threads to the mounting holes.

At present, one out of twenty switch rods rub on the housing due to the tolerances of the switch parts and housing hole. This problem was solved for the present by reaming the housing hole. As built now, the switch has three parts that are bolted together: the support block, the stop block, and the support plate. For the AN/ALM-262A, it is proposed that these parts be combined into one part. This would tighten tolerances considerably, thereby, reducing the housing rubbing problem appreciably.

Cap

The cap is shown in figure 14. Each of the five plunger switches is terminated with a cap. The cap was used to turn the plunger switch, either by hand or with a hex driver. The cap was attached to the rod of the plunger switch using a setscrew.

The cap presented two problems, one visual and one mechanical. When the Air Force received the first tests sets, it claimed that the dot indicator on the cap was not visible enough and requested the color be changed. ARDEC then repainted 760 caps, changing the color of the dot from white to red. The mechanical problem with the cap was that its setscrew did not hold it on the rod well. To correct this problem, the setscrew and its hole were made larger. This will be reflected in the AN/ALM-262A cap drawing.

Printed Circuit Board Assembly

One of the printed circuit board (PCB) assemblies, board 4, is shown in figure 15. Four such boards are mounted on a motherboard. This combination was held by the chassis assembly. The chassis assembly, through its flange, was attached to the roof of the housing. In addition, there was a smaller PCB that attaches to the base plate with two standoffs.

One problem that was encountered with the PCB assembly was difficulty in plugging into its mating connector. Close examination revealed that the PCB connector was not properly soldered to the PCB. In some areas there was a small space between the PCB and the PCB connector, which resulted in the permanent distortion of both components. Instructions were issued to rigidly clamp the PCB and its connector together at the time that one was soldered to the other. After this was done, the problem was greatly alleviated.

Another problem with the PCB assembly was malfunctioning. To date, 20 PCB assemblies out of more than 300 manufactured, malfunctioned when tested. The steps in the production of the PCB assemblies were as follows: (1) the electronic components were mounted on the PCB, (2) the components were soldered to the PCB, (3) the PCB was functionally tested, (4) any defect was then corrected, and (5) the PCB was conformally coated. Testing before conformal coating was conducted because it was much more difficult to repair a PCB once it was coated. Unfortunately, all the PCB failures occurred after coating. The explanation for these failures seems to be cold solder joints that were aggravated by the conformal coating. The only solution for this problem is an even closer examination of all PCB solder joints.

Electrical Troubleshooting

In addition to the aforementioned mechanical problems, 15 of the 95 test sets manufactured to date had electrical problems. The symptom of a fault was the improper operation of at least one of the LED indicators. The faults fell into seven categories that will now be discussed in turn:

- LEDs were always off regardless of the test sequence switch position. This was the most common fault having occurred in four test sets. The fault was caused by a damaged voltage regulator. The voltage regulator either was received defective or was damaged while its terminals were soldered. The assemblers were instructed to use more caution when soldering the wires to the voltage regulator terminals.

- A second fault was caused by a defective on/off switch. While soldering wires to this switch the heat melted its plastic parts slightly which permanently distorted them. The assemblers were instructed to use more caution when soldering the wires to the switch terminals.

- A third fault was caused by the interchange of two wires, which channeled the power to the wrong place. The wires were attached to terminals S1-D1-C1 and S1-D2-C1 on the test sequence switch. Because of these designation similarities, the assemblers were instructed to read the wiring list more carefully.

- The fire pulse LED did not flash for all fire pulses. The faults were caused by opening from cold solder joints at some of the positive terminals of the ICSs. The assemblers were instructed to solder to the positive terminals more carefully.

- Another fault was caused by open pins in the Winchester connector. This connector was on PCB 6. This fault was caused by flux drying and becoming an insulator inside the pins. The assemblers were instructed to clean the pin area well after soldering all the wires to the pins.

- In some cases, the system-not-reset LED was always off whether the system was reset or not. This fault was caused by interchanging the wires going to wiper arms C2 and C3 of the test sequence switch. As noted before, the assemblers were instructed to read the wiring list more carefully.

- The stray voltage LED was always on. Careful study of board 5, the motherboard, determined that this condition was caused by shorts from solder in three places. The assemblers were instructed to use more care when soldering.

Testing

Functional testing was performed at two stages of manufacture. Each of the 750 PCB assemblies were tested prior to conformal coating. Each completed test set was operated in all modes to assure proper functioning.

The method for checking the individual PCBs was unwieldy, erratic, and physically strenuous. It required that the PCB to be tested be inserted into a test set, and the test set be inserted and tightened into a dispenser assembly using stud nuts. If a PCB failed its test, it could not immediately be declared damaged. The PCB had to be reinserted and the stud nuts retightened, to assure that bad connections were not the problem in the first place.

To attain a more accurate and quicker testing, a modified test set is required. This test set would have one cable and a connector replacing the 30 ICSs and their associated wiring. The fire pulse generator, the AN/ALE-40, would have a mating connector for interfacing with the test set. This test set-up would eliminate lifting the test set to the dispenser assembly and the tightening of stud nuts. The test set would simply lie on a bench and test PCBs in that position.

CONCLUSIONS

Although U.S. Army Armament Research, Development and Engineering Center (ARDEC) is not a manufacturing facility, limited production of electronic equipment can be accomplished to facilitate the work of the Army and other Government agencies. The following enumeration shows the major problems encountered in producing the AN/ALM-262 and what lessons were learned, that were either applied or will be applied, to improve future production.

1. Housings - The most expensive parts of a system must be studied in depth first when starting a project. Because this was not done on this program, two versions of the front panel resulted. The initial engraving was smeared and irregular. Whenever engraving has to be done, a sample of the material to be used should be engraved as early as possible to forestall any difficulties.

2. Impulse cartridge simulator (ICS) - The ICSs could not be easily assembled with simple mechanical tools. Whenever difficult assembly has to be done, it should be done in a specialized ARDEC facility or by a contractor.

3. On/off switches - Overheating when soldering to switch terminals distorted the plastic parts of the switch. Special mechanical techniques must be used whenever delicate parts are soldered.

4. Knobs and caps - The knobs and caps did not hold on well to their respective shafts. In the future, the shaft holes must be more closely mated to the shafts, and the largest setscrew possible must be used to assure the best shaft grip possible.

5. Chassis and flange assemblies - Discovering loose or defective clinch nuts after these assemblies were finished resulted in a slow and laborious repair process. Clinch nuts must be tested immediately after attachment to assure they were peened properly and are not defective.

6. Top and bottom access cover assemblies - After the riveting was done on these assemblies, it was seen that it could have been done less expensively by a contractor. Each assembly in a system must be studied at the beginning of a program to determine who can produce it most economically.

7. Voltage regulator assemblies - The anodization from parts of the thermal power coolers of these assemblies had to be removed by a tedious sanding process. This experience suggests that prior to beginning any production, all metal parts be studied to assure they have the proper surfacing.

8. Plunger switch - Two improvements are proposed for this component. Threading the plunger switch holes will make it easier to mount, and combining three of its parts into one will give it closer dimension tolerances, which will greatly improve its housing mounting problem. Every metal part should be studied to determine if it can be redesigned to make it more efficient and easier to handle.

9. Printed circuit boards (PCB) - To attach the PCB connector properly on the PCB required the development of a special technique. All assembly processes should be examined from the viewpoint of obtaining the best product.

10. Testing - The unwieldy way in which the PCB and the test sets had to be tested suggests that test equipment should be designed and proved out at the beginning of production.

2-CONNECTOR PLUG
ELECTRIC MS3106F125-3P

2-TEST SET, COUNTERMEASURES
DISPENSER ASSEMBLY, AN/ALM-262
12937678

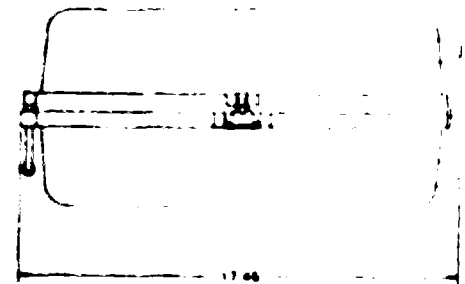
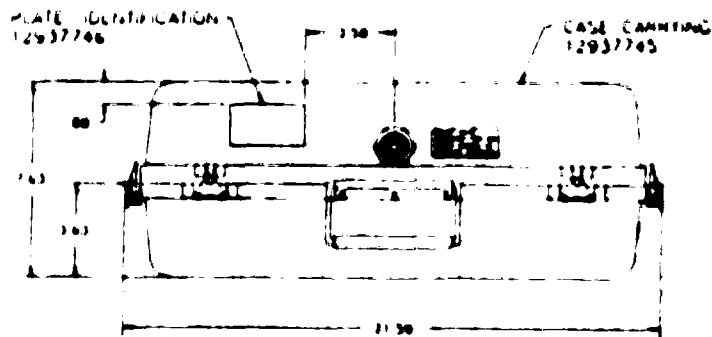
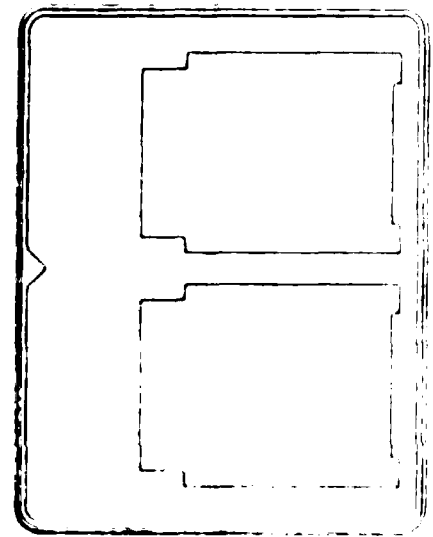
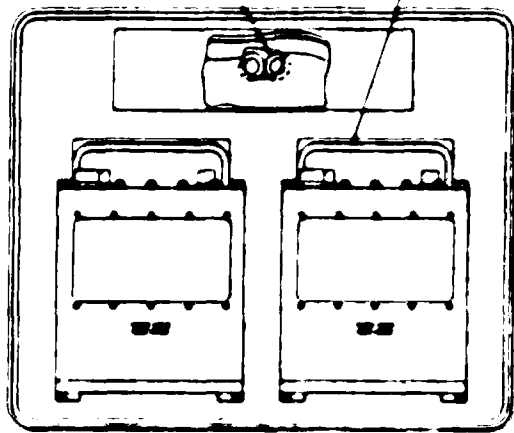


Figure 1. Countermeasures dispenser test set

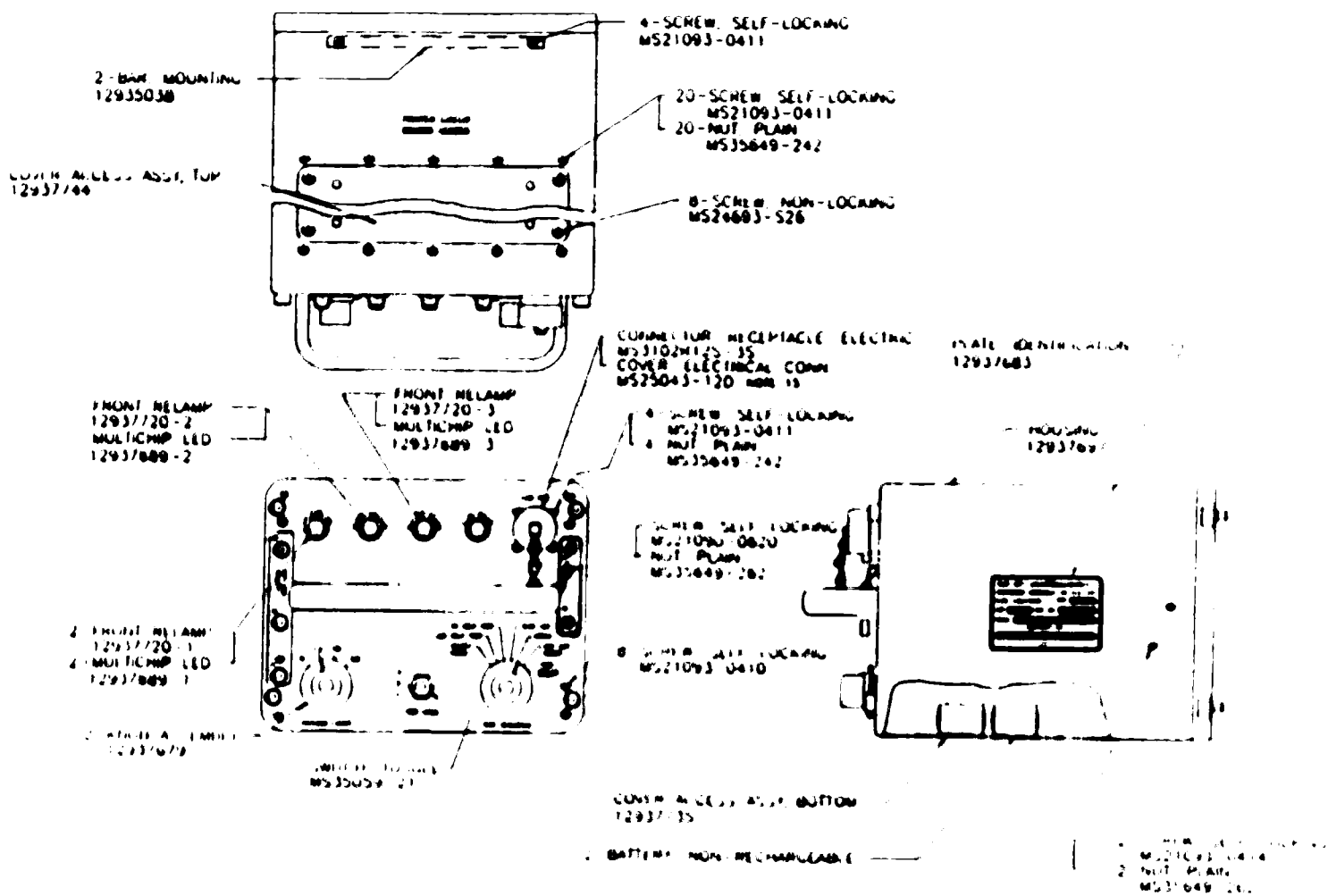


Figure 2. Countermeasures dispenser test set assembly

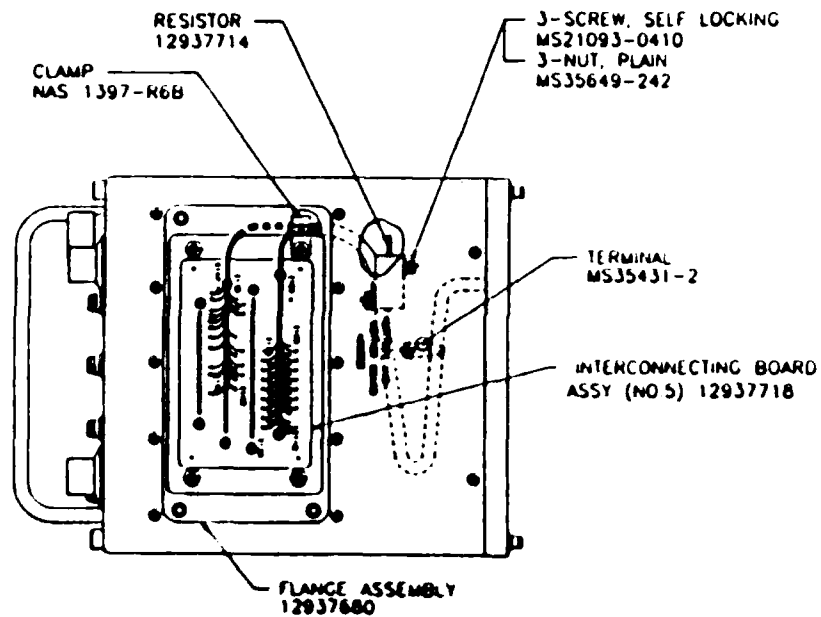


Figure 3. Countermeasures dispenser test set assembly, bottom view

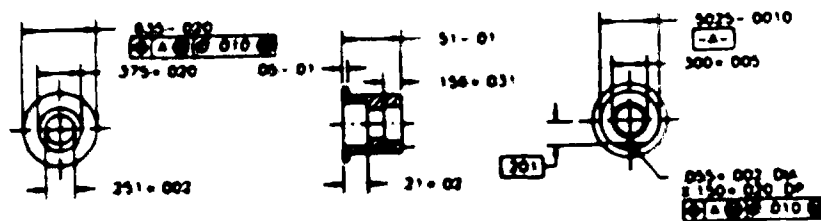


Figure 4. Impulse cartridge simulator

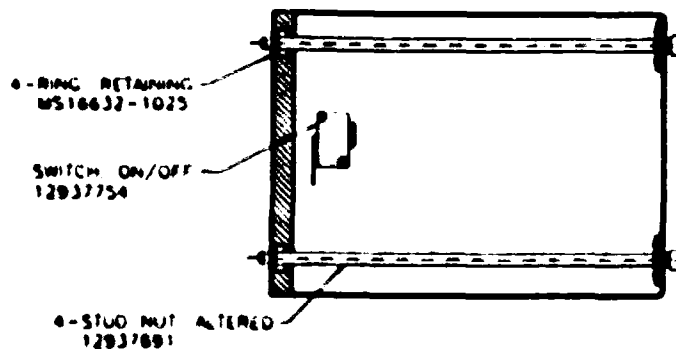


Figure 5. Countermeasures dispenser test set assembly, right side view

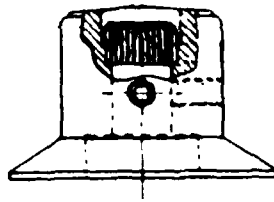


Figure 6. Knob assembly

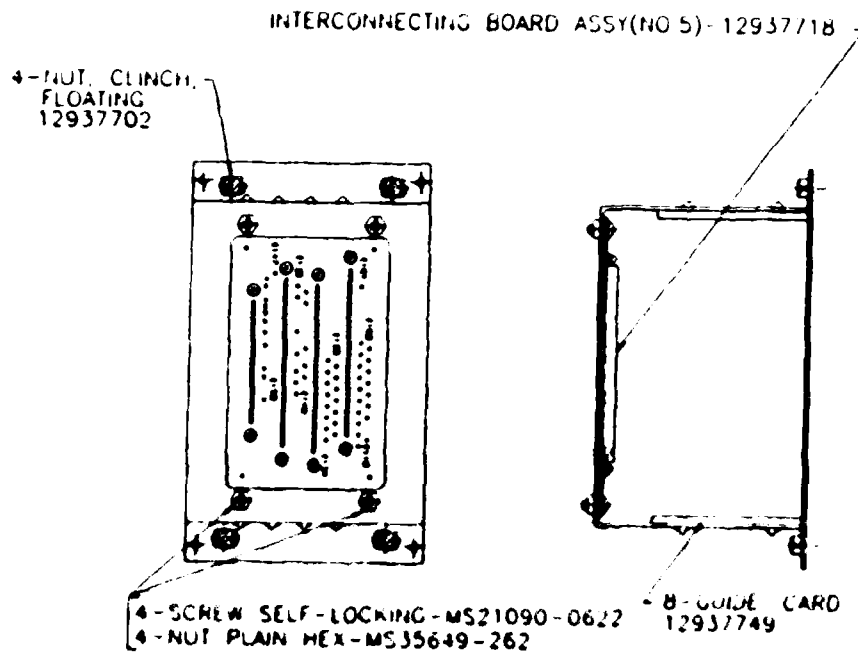


Figure 7. Chassis assembly

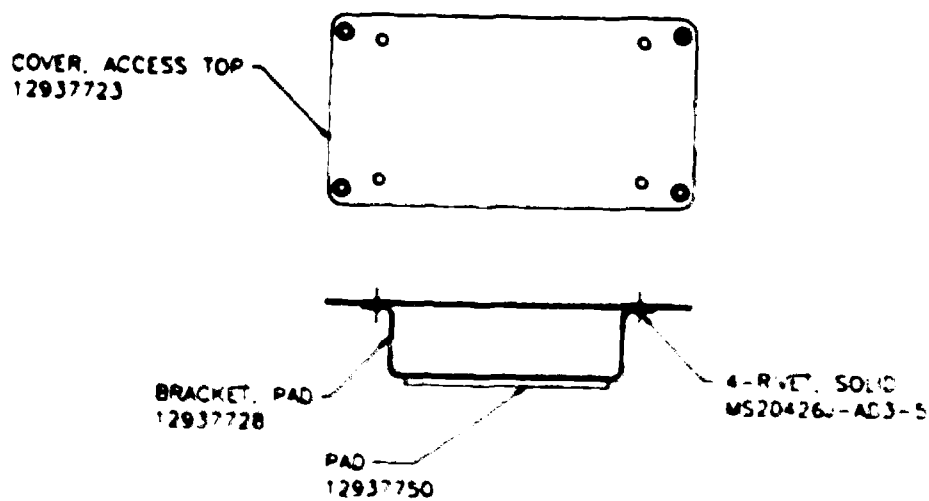


Figure 8. Top access cover assembly

4-NUT, CLINCH, FLOATING
12937702

FLANGE-12937701

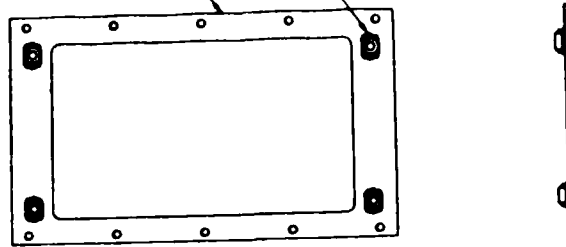


Figure 9. Flange assembly

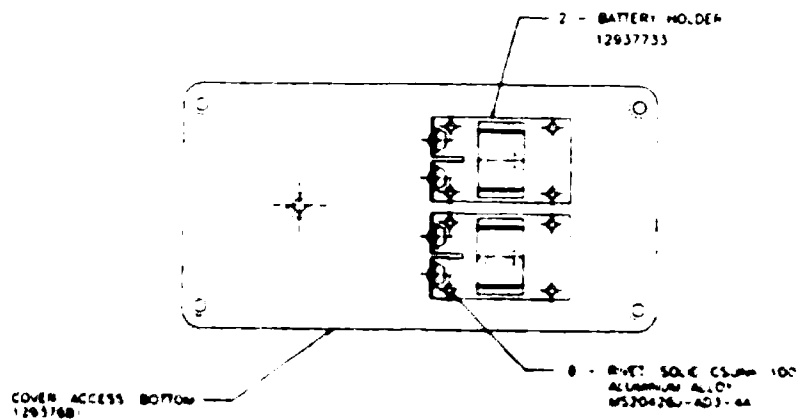


Figure 10. Bottom access cover assembly

2-SCREW, SELF-
LOCKING CROSS
RECESSED
MS21090-0624
2-NUT, PLAIN
MS35649-262

THERMAL POWER
COOLER
12937757
BASE & TOP



TOP
BASE

VOLTAGE
REGULATOR
12937756



Figure 11 Voltage regulator assembly

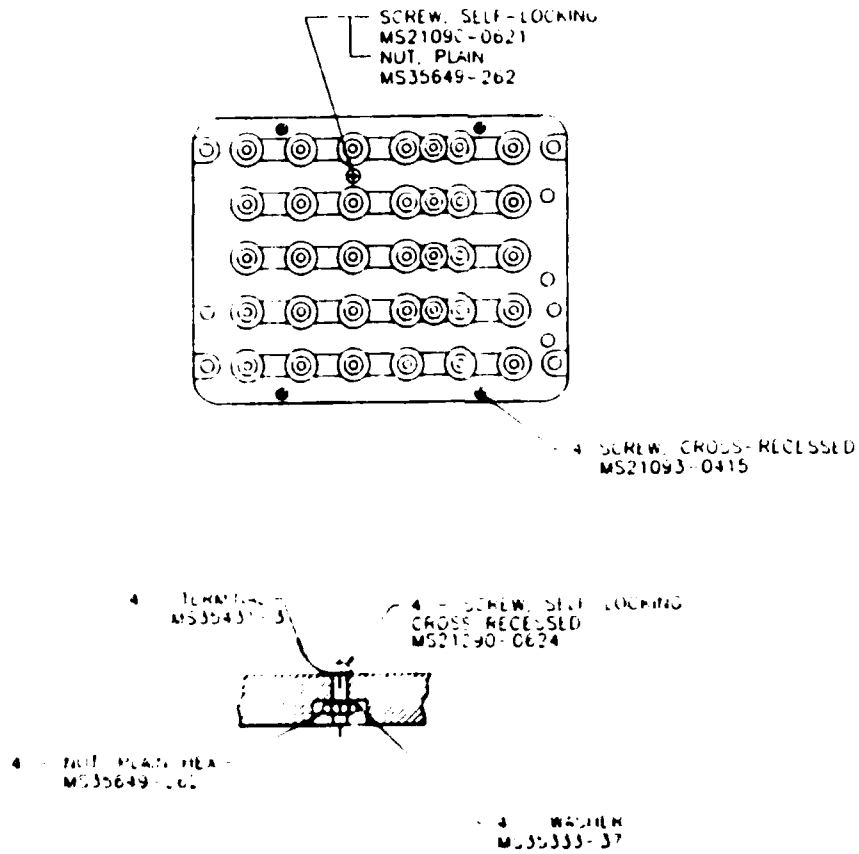


Figure 12. Base plate assembly

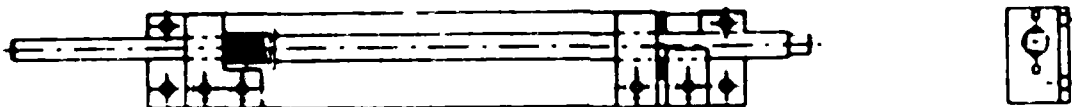


Figure 13. Bracket assembly

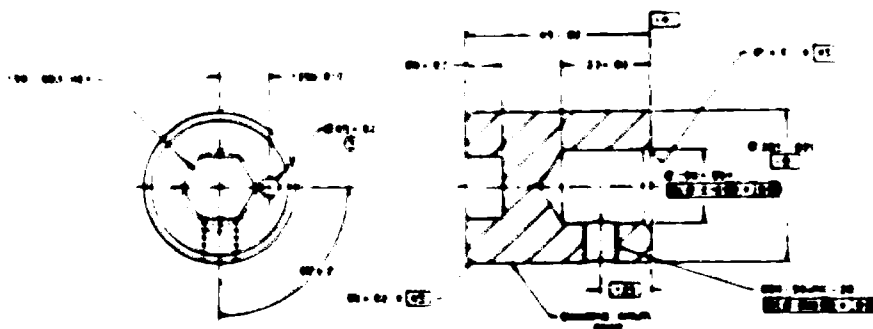


Figure 14. Cap

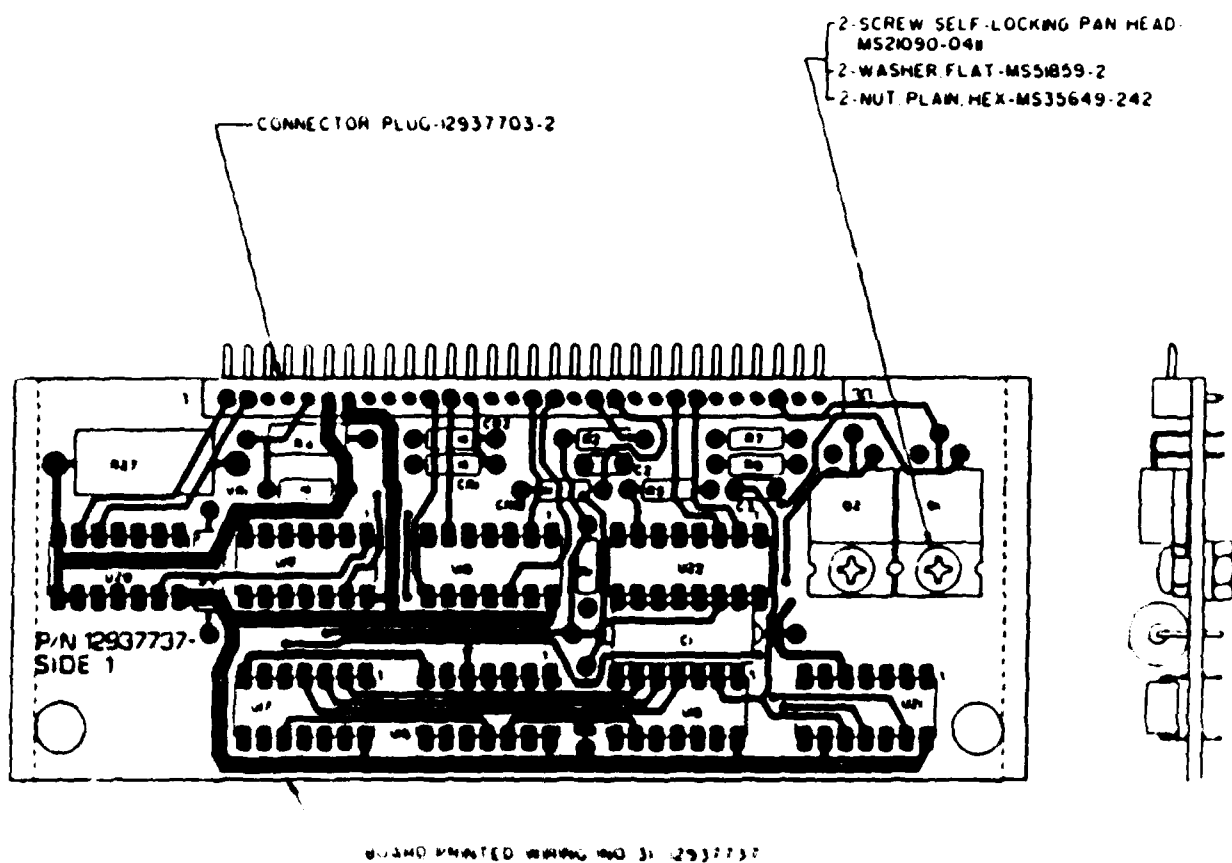


Figure 15. Printed circuit board assembly

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